

the Physical Laboratory of Christiania, and during the last two years Mr. S. Svendsen assisted in the work. About 1880, Prof. C. A. Bjerknes received from the Norwegian Government a private laboratory, where the experiments were arranged by the author with the assistance of Mr. J. L. Andersen. The result of these facilities was the construction of an elaborate instrument for measuring the attractions and repulsions of bodies pulsating in liquid. The generator consists of a system of pumps or drums operated on as bellows by cranks worked by a handle. These alternately force air in and out of the "pulsators," which may consist either of elastic balls, drums, or similar arrangements suspended in the water by a "pulsation balance," and the whole apparatus is now supplied by Ferdinand Ernecke, of Berlin. Another form of apparatus is described suitable for studying bodies oscillating in water without change of volume. Methods are also described of rendering the stream lines visible, and diagrams are shown illustrating the resemblance of these lines to magnetic lines of force.

The description of the experiments occupies the second part of the book. The first part consists of a summary of the main results, both quantitative and qualitative, which were established in vol. i., treated by elementary methods only, and it serves the purpose of enabling the physicist to read the present volume without studying its more mathematical predecessor. For such a reader the third part will have considerable interest, for it deals with the analogy of hydrodynamical phenomena with those of electrostatics and magnetism. Prof. C. A. Bjerknes's original discussions of these analogies having been given at a transition period in the development of electrical science, the writer of the present volume has largely remodelled the arguments in order that they may be studied in the light of modern electrical views. Between hydrodynamical and electric or magnetic fields of force, a close analogy exists *except in regard to the sign of the force*. The stream lines due to spheres executing pulsations of the same phase are identical with the lines of force due to like charges, but the pulsating spheres attract one another while the electrified spheres repel one another. If the pulsations are of opposite phases, the stream lines are the same as the lines of force of oppositely charged bodies, but the force is repulsive instead of attractive. Owing to this difference, the hydrodynamical field is to be regarded as affording a representation rather than an explanation of electric and magnetic fields, and as Prof. V. Bjerknes points out, a negative representation is still a representation, and it may admit of all the uses of a positive one.

Prof. V. Bjerknes has uniformly adopted the Heaviside system of "rational" electrical units, and he points out the great simplifications that arise from the use of this system, expressing his regret that the existing units were adopted before the advantages of the rational system had been fully appreciated.

The book will be read with much interest by physicists, and the reproduction of some of the experiments in the lecture room suggests a useful aid to the teaching of electricity.

G. H. BRYAN.

#### FARM ACCOUNTS.

*The Farmer's Business Handbook.* By I. P. Roberts. Rural Science Series. Pp. xiii+300. (New York: The Macmillan Company; London: Macmillan and Co., Ltd., 1903.) Price 4s. 6d. net.

THIS volume of the Rural Science Series consists firstly of an elementary account of book-keeping suitable to a small farm, and secondly a discussion of such legal questions as leases, tenant right, highways, fences, mortgages, taxes, &c., with which an ordinary farmer is likely to become conversant in the course of his business. This latter portion of the book is naturally only applicable to the United States, and though succinctly and clearly written, can be of little service to the English reader. In the earlier section of the book a system of book-keeping is set out by which the farmer can ascertain not only his profit or loss as a whole, but the result of his operations on each field or in each section of his business. The usual method of double entry is employed, though only day book (for which the American equivalent is apparently "blotter") and ledger are kept. The explanations are clear and simple, and may be read with profit by students who are beginning formal book-keeping, and are getting confused over the problem of Dr. and Cr. But we are by no means convinced that the ordinary system of double entry is the best method of handling farm accounts; naturally it can be made to deal with them, and for the cash account nothing different is wanted, but it is an extremely cumbersome means of ascertaining the profit or loss on individual crops or classes of live stock. Farmers are often reproached, and justly enough, with not keeping proper accounts, but it is not quite so easy a matter as in a business where all the items are in sight. So many of the figures must be estimates depending upon the judgment of the farmer; first of all the annual stock-taking has to be a valuation, in which market fluctuations have, or have not, to be considered, according to the purpose of the account. For example, a man has a breeding flock the number of which remains constant; in ascertaining his profits upon sheep-breeding it is best to take the value of the flock as constant, but in ascertaining his financial position at a given moment, he must re-value the flock at current rates. Again, many operations upon a farm are performed as much for their contingent advantages as for immediate return; the dung and cultivations given to the root crop have their value throughout the rest of the rotation; cattle are fattened for the sake of the manure they produce.

To one point the author of this book very properly gives special prominence, the item of household expenses; the house rent, the milk, potatoes, &c., consumed, the labour spent, are very often not taken into account at all, and the farmer sometimes comes to the conclusion that his farm is not paying when he is really living beyond his income. On the whole we believe that the ideal system is to open a ledger account for all cash transactions and for the house, and to keep separate running or progress accounts against the main branches of his business, such as the dairy

herd, sheep, crops, the latter account being occasionally specialised for a few years in order to ascertain whether a particular crop or field is paying its way. But we commend to the teachers of book-keeping in such of our agricultural colleges as possess a farm the problem of devising with an open mind an improved system of farm accounts, which shall be simple, actual, and helpful.

### OUR BOOK SHELF

*The Rôle of Diffusion and Osmotic Pressure in Plants.*  
By B. E. Livingston. Pp. xiii+149. (The University of Chicago Press, 1903.)

BIOLOGISTS who attach importance to the bearing of physics on their science must be gratified with the increasing number of books now appearing on such subjects as are treated in the book before us.

Mr. Livingston's short book is clear and readable, and contains a simple and concise sketch of much of the physics of diffusion and solution. The matter is well put, and difficulties are avoided. But concise treatment has its disadvantages, and, in one or two places, a false conception might be obtained from the author's descriptions. Thus there are notable exceptions to the rule that the particles of substances are brought closer together during the change from the liquid to the solid state. And it is scarcely fair to assume that the greater closeness of the particles is the cause of the greater rigidity of solids.

The limited space available in the book has apparently led to the exclusion of matter which it would be essential for the biologist to be acquainted with, and he should supplement it with the study of some text-book of physical chemistry. With regard to recent work, it must be regarded as unfortunate that the writer leaves out all mention of Brown and Escombe's work on diffusion through perforated septa from the physical part of the book, while in part ii., on physiological considerations, this investigation receives a bare mention by name in a small footnote. One would have thought that these authors' results would have been fully discussed as having a most intimate connection with the subject, and as bringing a completely new light to bear on our ideas of the diffusion of gases and of dissolved substances in plants.

The chapter on the terminology applied to solutions of different concentrations is very lucid, and should prove most useful to biologists.

In part ii. an account of turgidity and of absorption and transmission of dissolved substances in plants is given. Much information is imparted in a small space considering how nebulous are our ideas on the actual part played by the vital osmotic membranes of plants.

In the reviewer's opinion, far too much weight is accorded to Westermeier's and Godlewski's hypothesis explaining the ascent of water in trees. These writers assumed that the elevating force is to be found in the exudation pressure of the cells of the wood, cortex, and medullary rays. The physical relations of these cells to the water capillaries of the plant render the idea that the cells at different levels act as relay pumps impossible.

The theory of a tensile transpiration current is alluded to, but unfortunately it is criticised in the light of Copeland's undoubtedly misleading experiment.

The later chapters of the book are devoted to the osmotic effects of the medium on plants, and summarise most interestingly the recent results of osmotic and chemical fertilisation.

H. H. D.

*Mechanical Refrigeration.* By Hal Williams, A.M.I.Mech.E., A.M.I.E.E. Pp. xiii+406. (London: Whittaker and Co., 1903.) Price 10s. 6d.

THIS book, which is devoted mainly to practical study of mechanical refrigeration and cold storage, should have a wide circulation, dealing as it does with a growing industry of which the literature, so far as text-books are concerned, is remarkably scanty. It opens with two chapters on the theory of heat engines and refrigerating machines. The first of these might well have been omitted, as it merely contains a series of definitions which can only be intended for a trader who is totally ignorant of the elementary theory of heat, and are somewhat apt to convey a wrong impression. The second chapter, on thermodynamics, is carefully worked out, the section dealing with the heat change consequent on the performance of internal work by the fluid being particularly interesting. A chapter devoted to the history of the subject leads to a short study of the methods of preparing the modern refrigerants, liquid carbonic acid and ammonia, and a description of the more important type of refrigerating machinery. In the latter section the author has confined himself to an account of ammonia and carbonic acid plant, and in this, considering the dimensions of the work, he is undoubtedly justified. Fifty pages of the book deal with the auxiliary plant necessary in a cold storage works. Finally, insulation, ice making, the construction and arrangement of cold storage works, and the application of methods of refrigeration to commercial processes are fully dealt with. The author wisely omits all mention of liquid air and its problematical applications. The book is well illustrated by means of photographs and diagrams, and the text is clear and concise.

M. W. T.

*Die stammesgeschichtliche Entstehung des Bienenstaates sowie Beiträge zur Lebensweise der solitären u. sozialen Bienen (Hummeln, Meliponinen, &c.).*  
Herausgegeben von Dr. H. von Buttel-Reepen. Pp. xii+138. (Leipzig, 1903.) Price 2.40 marks.

THIS is a book that should not be overlooked by those who are interested in the many important questions that are opened up by the habits of social insects. The author points out that the highly developed organisation of the life of the hive-bee does not stand alone, but may be traced up from the commencement of mere association of solitary species, through the less organised communities of humble-bees, &c., to its perfection in the hive-bee. A great number of outlying questions respecting parasitic bees, wax-secretion, &c., are also more or less fully discussed. The author is very anxious to eliminate, so far as possible, the natural tendency to anthropomorphise the actions of bees to too large an extent, and appears to take the view that inherited tendencies have to a large extent rendered their actions subjective and automatic. The index is very full, and is preceded by a list of nearly 200 books and papers dealing with the subject, which cannot fail to be of great value to any serious student of bee-life.

*The Mind of Man.* By Gustav Spiller. Pp. xiv+552. (London: Swan Sonnenschein and Co., Ltd., 1902.)

MR. SPILLER suffers apparently from the constitutional defects of extreme prolixity, and a marked contempt for the views of psychologists who have the misfortune to prove themselves "unscientific" by disagreeing with himself. The reader who is ready to overlook these deficiencies will find much interesting discussion of the principal problems of psychology in his book, though scarcely, I think, any considerable fresh contributions to the science. The author's fundamental point of view may be indicated by his definition of